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Research Article

Effects of glazing and *Arthrospira platensis* on physical and chemical characterization of *Litopenaeus vannamei* fillets during frozen storage

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Abstract

In the current study, glazing with water and *Arthrospira* (*Spirulina*) *platensis* extract (SPE) were used to keep the quality characteristics of *Litopenaeus vannamei* intact during frozen storage. For this purpose, fresh shrimps were dipped into water diluted with 0.3, 1.0, and 1.3% of SPE solutions before freezing, then glazed and stored at -18°C for 150 days. Quality loss of shrimp was measured by pH, peroxide value (PV), total volatile basic nitrogen (TVB-N), thiobarbituric acid (TBA), textural properties, (hardness and cohesiveness) and sensory characteristics. The variation range of pH, PV, TVB-N, and TBA after 150 days increased to 7.67–7.82, 2.69–2.75 meq per kg O_2 lipid, 28.04–29.92 mg/100g, 2.48–2.81 mg per kg MDA, respectively. The values of cohesiveness, hardness and sensory of all groups decreased after 150 days. Results showed that compared to the unglazed control samples, glazing treatment reduced the quality loss of shrimp during the 150 days of frozen storage. Results also illustrated that *Spirulina* glazed shrimp samples had lower TVB-N, PV, TBA, and higher textural and sensory properties compared to the other treatments.

Keywords: *Litopenaeus vannamei*, *Spirulina platensis*, Glazing, Quality, Frozen storage

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Introduction

Seafood species are nutritious since they are rich in proteins and other nutrients, including peptides, essential amino acids, long-chain omega-3 polyunsaturated fatty acids, carotenoids, vitamins, and minerals such as calcium, copper, zinc, sodium, potassium, selenium, iodine, and others (Jasour *et al*., 2015; Venugopal, 2018).

Shrimp is one of the most widely consumed seafood all over the world for its positive culinary quality and nutritional value. Consuming shrimp and other seafood products can be useful to prevent some diseases such as cardiovascular diseases (Chouliara, 2008). However, the shrimp is likely to spoil and decay during shipping, in the selling process and storage conditions. One of the causes of shrimp spoilage is bacteria contamination, hydrolysis of endogenous protease and melanosis (Qian *et al*., 2013). Traditionally, freezing, water glazing, using preservatives (such as phosphates), and different packaging materials have been used to control the spoilage process (Okpala *et al*., 2014). Recent studies also show that natural extracts such as algae extracts can also improve the quality of shrimp products.

Arthrospira (*Spirulina*) is a species of blue-green algae that contains large amounts of essential vitamins, fatty acids, and minerals such as iron, magnesium, selenium, and zinc (Ghaeni and Roomiani, 2016). Previous reports demonstrated that the *Spirulina* extracts contain phenolic and phycobiliprotein compounds and showed antioxidant and antimicrobial activities (Okpala, 2015; Parashideh *et al*., 2014). However, the efficacy of glazing with *Spirulina* extract to control spoilage in shrimp during frozen storage has not been reported yet.

Therefore, the aim of the present study is to investigate the effect of glazing with *Spirulina* extract on the chemical (TVB-N, PV, and TBA), textural (cohesiveness and hardness) and sensory properties of *L. vannamei* during the frozen storage for 150 days.

Materials and methods

SP extract preparation

S. *platensis* powder was purchased from Barij Essential Pharmaceutical Company (Kashan, Iran). Initially, 2.5 g of *Spirulina* powder was weighed and added to 200 ml of water. The mixture was heated cautiously until the volume was reduced to 50 ml. The hot solution was twice filtered at a suction pump and the filtrate was transferred to a 50 ml volumetric flask.

Shrimp preparation and treatment

The fresh and Organic *L. vannamei* shrimp was purchased from the local market and transported frozen to the central Laboratory of Iran Veterinary Organization. In the laboratory, the shrimps were washed, headed and deveined by hand and finally divided into five groups and treated as follows:

Group 1: unglazed shrimps (NG)

Group 2: water glazed shrimps (WG)

Groups 3, 4 and 5: *Spirulina* solution (0.3, 1.0, and 1.3%) glazed shrimps (SG)

For the glazing process, the samples were first immersed in water and *Spirulina* solution for 30 seconds and then dripped for 5 s. After glazing the samples were stored at –18°C for 150 days and chemical, textural and sensory evaluations were performed every 30 days.

Chemical analyses

pH determination

5 g of homogenized shrimp samples were mixed with 45 ml of distilled water and then the pH was measured using a pH meter (CRISON Instruments, Barcelona, Spain) at ambient temperature. Three measurements of samples were performed for each treatment.

TVB-N determination

TVB-N content of shrimp samples were determined using the method reported by Goudlas and Kontaminas (2005) with the use of a Kejeldahl apparatus. The TVB-N value was expressed as mg per 100g shrimp flesh. Three measurements of samples were performed for each treatment.

PV determination

PV of the samples was estimated as described by AOAC official method (2005). A volume of 25 mL of acetic acid: chloroform solution (3:2 v/v) was added into 5g of minced shrimp meat and mixed in saturated potassium, iodide starch solution, and distilled water in volumes of 0.5, 0.5, and 30 mL, respectively. Titration of released iodine with 0.01 N sodium thiosulphate was held until the intense blue color disappeared. PV was calculated using a previously reported formula. Three measurements of samples were performed for each treatment.

TBA determination

The distillation method reported by Namulema *et al*. (1999) was used to determine the degree of lipid oxidation in shrimp samples. Lipid oxidation was measured using thiobarbituric acid (TBA values), which are expressed as mg per kg malonaldehyde shrimp meat. Three measurements of samples were performed for each treatment.

Textural properties

The texture profile analysis of the shrimp samples was performed using a TA-XT2i texture analyzer. Shrimp samples were compressed twice with a cylindrical probe of 25 mm diameter, at 1 mm/s speed, and with 50% compression of the original height between the flat plates. Six measurements of samples were performed for each treatment.

Sensory evaluation

Sensory properties of control and treated shrimps were evaluated based on the method reported by Simeonidou *et al*. (1997). For this, ten experienced panelists (5 men and 5 women) were chosen to evaluate the quality of the samples. Samples were steam-cooked for 20 minutes and served warm to the panelists. Sensory properties were scored on a 5-point hedonic scale (5: very good, 1: very bad).

Statistical Analysis

Results were presented as mean±standard division (SD) and the statistical test was done using SPSS 26.0. One-way analysis of variance (ANOVA) and Duncan were used to detect significant differences between treatments in the frozen storage period.

Results

pH determination

Figure 1 shows the pH values of NG, WG, and SG shrimp samples during frozen storage. The range of pH on day zero of different groups was 6.18–6.53 and then increased up to 7.67–7.82 on day 150.

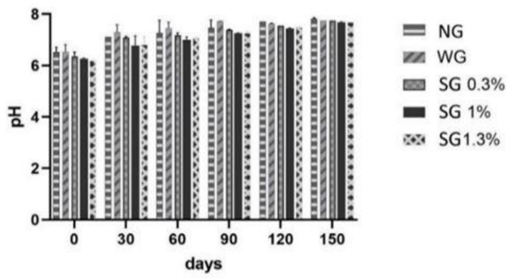

Figure 1: pH changes of unglazed (NG), water-glazed (WG), and *Spirulina*-glazed (SG, 0.3, 1.0, and 1.3%) *L. vannamei* during frozen storage.

TVB-N determination

TVB-N is one of the important seafood quality indicators and is related to spoilage by bacteria and the activity of endogenous enzymes (Shi *et al*., 2019). The changes of TVB-N in NG, WG and SG shrimp samples during frozen storage are shown in Fig. 2. The range of TVB-N on day zero of different groups was 11.75–12.30 mg/100g and then increased up to 28.04–29.92 mg/100g on day 150.

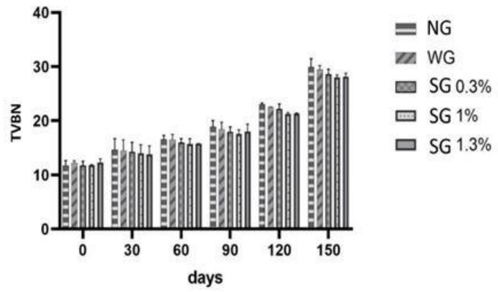

Figure 2: TVB-N changes of unglazed (NG), water-glazed (WG), and *Spirulina*-glazed (SG, 0.3, 1.0, and 1.3%) *L. vannamei* during frozen storage.

PV determination

The PV was used to measure the formation of primary lipid oxidation products that determine the extent of lipid oxidation at the initial stages of oxidation. Figure 3 shows the PV values of NG, WG and SG shrimp samples during frozen storage. The range of PV on day zero of different groups was 0.97–1.27 meq per kg O_2 lipid and then increased up to 2.69–2.75 meq per kg O_2 lipid on day 150.

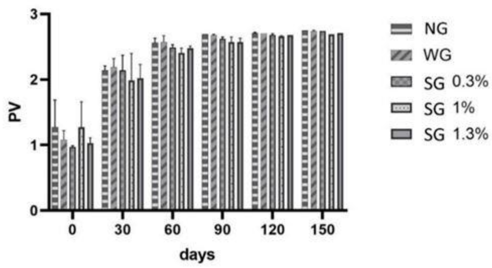

Figure 3: Changes in PV of unglazed (NG), water-glazed (WG), and *Spirulina*-glazed (SG, 0.3, 1.0, and 1.3%) *L. vannamei* during frozen storage.

TBA determination

TBA is a valuable test for measuring the secondary oxidation products of lipid oxidation. The changes of TBA in NG, WG, and SG shrimp samples during frozen storage are shown in Fig. 4. The range of TBA on day zero of different groups was 0.45–0.52 mg per kg MDA and then increased up to 2.48–2.81 mg per kg MDA on day 150.

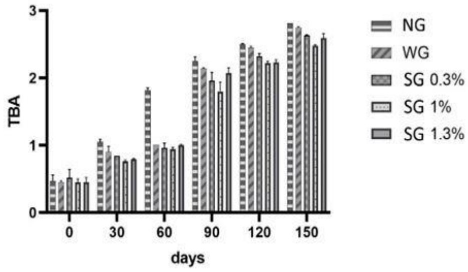

Figure 4: TBA changes of unglazed (NG), water-glazed (WG), and *Spirulina*-glazed (SG, 0.3, 1.0, and 1.3%) *L. vannamei* during frozen storage.

Textural properties

Figure 5 shows the textural properties (cohesiveness and hardness) of NG, WG, and SG shrimp samples during frozen storage. The range of cohesiveness on day zero of different groups was 493–586 and then decreased up to 346–455 on day 150. The NG shrimp showed the lowest cohesiveness and hardness. SG glazed groups (1.3%) showed higher cohesiveness values compared to other groups. The hardness on day zero was 0.33–0.42 and then decreased to 0.22–0.35 on day 150.

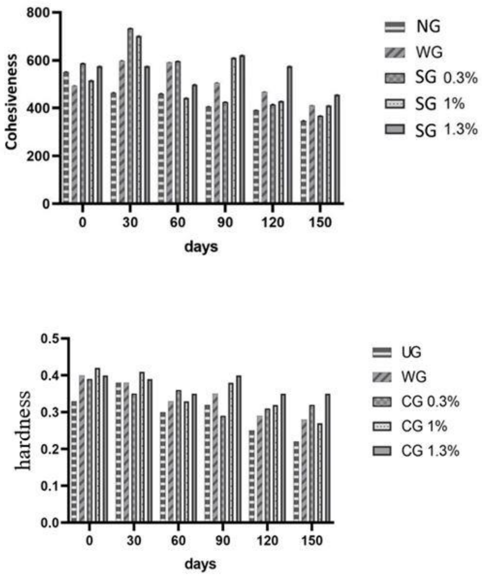

Figure 5: Textural properties (cohesiveness and hardness) of unglazed (NG), water-glazed (WG), and *Spirulina*-glazed (SG, 0.3, 1.0, and 1.3%) *L. vannamei* during frozen storage.

Sensory evaluation

The sensory properties of NG, WG, and SG shrimp samples during frozen storage are shown in Fig. 6. The sensory on day zero was 5 and then decreased up to 2.05–2.95 on day 150.

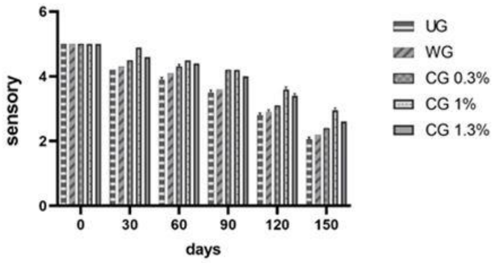

Figure 6: Changes in sensory of unglazed (NG), water-glazed (WG), and *Spirulina*-glazed (SG, 0.3, 1.0, and 1.3%) *L. vannamei* during frozen storage.

Discussion

The present study was conducted to investigate the effect of SPE as a glazing material on the quality of *L. vannamei* shrimp during frozen storage.

SG groups (1%) showed lower pH values compared to other groups. The acceptable limit of TVB-N content in seafood for human consumption is usually 30 mg/100 g. Based on these, all of the study groups were within the acceptable range. SG group (1%) showed lower TVB-N values compared to other groups. Lower TVB-N values in SG groups can be traced to the antimicrobial activity of *Spirulina* extract which controlled the bacteria growth and finally decreased the TVB-N. Shi *et al.* (2019) reported that using rosemary extract as a glazing layer on mud shrimp (*Solenocera melantho*) could lower the increase of TVB-N during frozen storage. The increase in PV was probably due to the faster rate of peroxides formation than the degradation of peroxides into secondary oxidation products. The NG shrimps showed the highest PV however, the lowest PV was measured in the 1%-SG glazed shrimp. Lower values of PV in shrimp may be attributed to the antioxidant properties of Spirulina extract. Shi *et al.* (2019) reported the anti-oxidative effect of rosemary-glazed on mud shrimp (*S. melantho*) during frozen storage. The acceptability limit of TBA for seafood is 7–8 mg per kg MDA. According to the results, the TBA values of all groups were under the acceptable limit throughout the storage period. The highest and lowest TBA were measured in the NG and 1%-SG glazed shrimps, respectively. The lower TBA value in 1%-SG glazed groups may be explained by the antioxidant activity of phenolic substances found in *Spirulina* extract. Çoban (2013) reported that glazing with rosemary oil could lower the TBA in rainbow trout fillet during frozen storage.

He and Xiao (2016) investigated the effect of tangerine peel (*Citri reticulatae pericarpium*) essential oils (TPEOs) as a glazing layer on freshness preservation of bream (*Megalobrama amblycephala*) during the super-chilling storage. Results showed that the glazing layers of TPEO can effectively slow down the degradation process of fish samples and the textural characteristics (hardness, springiness, and cohesiveness) of treated samples were higher than the control group. Generally, the acceptance of all groups decreased from day zero to day 150, however, they were at the acceptance level until day 120. SG glazed groups (1%) showed higher sensory properties scores compared to other groups.

The present study dealt with the control of changes in chemical and textural properties of peeled *L. vannamei* samples using glazing with *Spirulina* extract. After 150 days of frozen storage, NG shrimp exhibited higher chemical and lower textural and sensory properties compared to the WG and SG shrimps. From these results, we can surmise that glazing with *Spirulina* extract is effective in maintaining the quality of shrimp during the frozen storage.

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